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Reflection and Inquiry-based Teaching: Exploring Reflective Practices in Beginning Secondary Science Teachers

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REFLECTION AND INQUIRY-BASED TEACHING: EXPLORING REFLECTIVE PRACTICES IN BEGINNING SECONDARY SCIENCE TEACHERS

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Science teachers' reflections can be used as an opportunity to improve teaching through inquiry-based instruction (White, Frederiksen, & Collins, 2009), especially during their first years as teachers. Yet more work is still needed to support the development of beginning teachers' reflective practices (Russell & Martin, 2014). The purpose of this exploratory multi-methods study was to describe: (a) beginning secondary science teachers' reflective practices up to 4 years after completing their teacher education program, (b) the factors that might have an effect on these practices for participants, and (c) the connection (if any) between their inquiry-based instruction and reflective practices. We used open-ended interviews to describe the participants' reflective practices, applying Cartwright (2011) levels of reflection, and to determine factors that could support or limit their reflective practices. Additionally, we analyzed classroom observations coded using EQUIP to understand the teachers' inquiry-based teaching. We found that novice teachers can develop all levels of reflection, but they tended to be more unconscious when they teach a new course or teach out-of-field. Teaching experience, collaboration among teachers, and whole-school professional development can support science teachers to engage in higher levels of reflective practices. Finally, higher levels of reflection seemed to have a connection to more proficient use of inquiry-based instruction.

Keywords: Reflection, teacher induction, secondary school

INTRODUCTION AND RATIONALE

Secondary science teachers' reflection could support the process of learning how to teach science using inquiry-based instruction (White, Frederiksen, & Collins, 2009), especially in their first years as teachers (i.e., induction phase). Reflection, in the context of teaching, means to "look back" or "think back" at actions and teaching strategies, being able to assess these strategies for improvement and develop expertise focusing attention on certain elements teachers want to develop (Korthagen & Vasalos, 2005; McGregor, 2011; Marzano, Boogren, Heflebower, Kanold-McIntyre & Pickering, 2012). Moreover, reflection as part of a learning process, has a social component (Lovett, 2013). This is, it might start as an individual internalization, but it is enhanced when it is done in communication with others, such as peers or supervisors.

The purpose of this exploratory multi-methods study was to describe beginning secondary science teachers' reflective practices up to 4 years after completing their teacher preparation program. The research questions for this study were: What are beginning science teachers' reflective practices after finishing their teacher preparation program? What factors

may affect beginning science teachers' reflective practices? And, what is the relationship (if any) between reflective practices and inquiry-based instruction?

Theoretical framework

Teachers' first years are full of new experiences and learning. New science teachers come to their classrooms with a set experiences inside (e.g., as students, student teachers) and outside (e.g., personal interests) the school, content and pedagogical knowledge, and many expectations and hopes. As novice science teachers gather new experiences within the specific context of their science classrooms, teachers' reflection may support their process of meaning making (Duffy, Miller, Parsons & Meloth, 2009; Rusell & Martin, 2014). Applying the conceptual change framework, after a higher order cognitive task, such as teaching science as inquiry, teachers' reflection supports the process of accommodation and assimilation of new ideas and experiences (Russell & Martin, 2014). Moreover, teachers' reflection should involve a process of high levels of metacognitive thinking to transform teachers' cognitive conflicts and alternative conceptions into new learning (Duffy et al., 2009). In other words, reflection can enhance, modify, or adapt teachers' initial knowledge about science teaching, into new knowledge to improve their practice. Yet, more work is needed to support and understand beginning science teachers' reflective practices (Russel & Martin, 2014), especially when using high stakes science standards (e.g., NGSS) and inquiry-based instruction.

Teachers' reflection is a broad and complex construct that might involve several elements about science teaching. For example, reflection might involve thinking about teacher's mission, identity, beliefs, competencies, or behaviors (Korthagen & Vasalos, 2005). Therefore, to gain a better understanding of beginning teachers' differences on thinking about and capacity to use reflective practices, some scholars have suggested levels of reflection. Although Collin, Karsenti, and Komis, (2013) stated that reflective practices in all levels could be useful for teaching improvement, depending on the pedagogical circumstances, we found Cartwright's (2011) levels of reflection as a helpful analytic lens to view reflective practices (Table 2) and gain a better understanding of the qualities of reflection and possible connections to inquiry-based teaching.

RESEARCH METHOD AND DESING

We used an multi-methods exploratory research approach to conduct this study about beginning science teachers' reflective practices. We followed the requirements of the university's Institutional Review Board. For this study, the participants were beginning science teachers (0 to 4 years of experience), alumni from a university-based, secondary science education program in a Midwestern city in the United States during August 2016-May 2017. We contacted 64 alumni who graduated from the masters level (MAT) or undergraduate (UG) programs between 2013 - 2017. Fifteen teachers agreed to participate (10 females and 5 males; 12 of Western European descent, one Latino, one African American, and one Middle Eastern; two participants came from the UG, while thirteen from the MAT) (Table 1); all of them were participating or participated in some point in a larger longitudinal study about inquiry-based instruction.

Table 1. Summary of Interviewed Participants.

	Gender		Level			School	
	Male	Female	HS	MS	Both	High SES	Low SES
MAT	5	8	9	3	1	7	6
UG	0	2	2	0	0	1	1
Total	5	10	11	3	1	8	7

We conducted open-ended interviews (average of 50 minutes) from August 2016 to March 2017, and included questions to generate reflection about their concept of effective science teaching and factors that might affect their reflective practices, using a grounded theory approach. This is, the data collection and analysis occurred simultaneously using in-process and analytical memos. We transcribed all the interviews for analysis. For teachers participating in the longitudinal study, we observed their instruction at least four times during the school year 2016-2017, wrote detailed field notes, and coded (after a process of calibration) them using the EQUIP instrument (Marshall, Horton, Smart, & Llewellyn, 2008). This tool (EQUIP) analyzes four specific areas of inquiry-based teaching (i.e., instructional, discourse, assessment, and curriculum factors) in a scale 1 to 4, where 1 is labeled as "pre-inquiry" and 4 as "exemplary inquiry". We used 64 coded lessons from 11 participants.

Table 2. Levels of Reflective Practice Indicators for beginning teachers (Cartwright, 2011).

Unconscious Reflection (UR)	Conscious Informed Reflection (CIR)	Conscious Critical Reflection (CCR)
1. Learning as "transmitter of knowledge."	1. Seeks support from different sources (e.g., readings, colleagues).	1. Recognize different ways of approaching a problem.
2. Trial and error. Getting things done for now.	2. Recognizes his/her own feelings.	2. Use different learning strategies.
3. Little evidence, but the lesson appeared to run "smoothly."	3. Evaluates his/her own practice and modifies instruction.	3. Using theory to inform teaching.
4. Accepting intuition to assess effectiveness.	4. Using data to support teaching.	4. Taking risks, but willing to evaluate the results.
5. Considering only his/her feelings.	5. Experience informs teaching.	5. Comparing with other teachers or ideas.
6. Using generalizations or unsubstantiated statements.	6. Using experience as student with meaning as a teacher.	6. Open to other's ideas and criticism.

To identify the level of reflection used by the participants during the interviews, we analyzed them using protocol coding (Miles, Huberman & Saldana, 2014). In MAXQDA, we identified the descriptors listed by Cartwright (2011) (Table 2) in the interview segments. We tallied the number of descriptors found to classify the interview trending as uncounsious (UR), conscious informed (CIR), or conscious critical reflection (CCR). Because all the participants had coded segments in the three levels, we decided to use the level with the most segments. To find out factors that affected teachers' reflective practices, we used an interactive model (Miles et al., 2014); in MAXQDA first we used open coding to condense the data and then, with the themes that emerged, focused coding to reach conclusions. For trustworthy purposes, we used

the classroom observations we conducted from the longitudinal study to confirm our emerging themes. We hypothesized that years of teacher experience might have an influence on the level of reflection used by participants.

To find connections between the levels of reflection and inquiry-based instruction, we used the participants' EQUIP coded lessons. Because EQUIP uses an ordinal scale, we calculated the total mode for each participant, grouping the four tool's inquiry areas. We compared these modes with the level of inquiry practices.

ANALYSIS AND FINDINGS

We used the descriptors developed by Cartwright (2011) to identify segments and tallied these descriptors to identify trends (Table 3). Due to space limitations we provide a few examples of the range of teachers' use of reflective thinking practices.

Table 3. Example of coded segments of Unconscious (UR), Conscious Informed (CIR), and Conscious Critical Reflection (CCR).

Descriptor	Participant	Example of coded segments
Learning as "transmitter of knowledge" (UR-1)	David	*I like to bring something to kids that you can use as an example or applied when, in some point, you would have to lecture or explain things. You know, it's like... I like to have like a concrete example to bring…* (12/03/2016, line 50)
Using data to support teaching (CIR-4)	Frank	*I'll look at the grades and that indicates to me either those skills are or aren't being met.* (11/29/2016, line 27)
Using different learning strategies (CCR-2)	Betty	*I think it should be engaging as far as the kids are asking questions and the kids are trying to gather, collect data, generate data, the kids are doing the thinking where they're figuring out how to solve a problem but also they're talking with each other, they're discussing…* (12/01/2016, line 66)

The coded data showed that almost all of the 2nd-year teachers, the largest group in this study, tended to use CIR or CCR (Table 4). This is, teachers with more than one year of experience demonstrated more conscious reflection. Nevertheless, we found teachers with three and four years of experience using UR as well (e.g., Mary and David). Therefore, it seemed years of teaching experience might have an influence but be insufficient to explain the development or lack of change in how teachers engaged with reflective practices.

After each interview, we had a general sense of some participants' overall level of reflection. These teachers' interview analysis showed a strong trend in their number coded segments in one level of reflection. For example, Frank, a 2nd-year teacher, had 77% of his coded segments as CIR; or Jean, a 5th-year teacher, had 72% as CCR. Therefore, we could identify or have a general sense of the level of reflection most used by these participants, even before coding the interview or before tallying the coded segments. But, for other participants, it was difficult to predict their level of reflection after our conversation and analysis, and before tallying their coded segments. We noticed that for these participants the coded segments' trends were not that clear or dominant. In our tally and analysis, at least half (or close) of the coded

segments were one level of reflection and half were between the other two (we bolded these participants in Table 3). For instance, Paula, a first-year teacher, had 45% of her segments as UR and 55% between CCR and CIR. Although she had a largest percentage of coded segments as UR, more than half of her interview reflection was in a more conscious level of reflection. Or Betty, with 49% of segments coded as CCR, but 51% in the other two levels (40% as CIR and 11% as UR) (we added an arrow to show where the trend of the second half of the coded segments were). It was interesting to observe that second-year teachers identified as CIR, the biggest group of participants, two of the participants tended toward UR and two toward CCR. Again, reflection is a complex construct. It was clear that experience might help to deepen the level of reflection, but there were other actors that might have an effect in teachers' reflective practices.

Table 4. Participants' Levels of Reflection and Teaching Experience. Participants were categorized based on the highest number of coded segments in that level of reflection (% of coded segments).

Years of teaching experience	Unconscious reflection (% UR)	Conscious informed reflection (% CIR)	Conscious critical reflection (% CCR)
0	**Paula (45)** →		
1	←	**Steve (54)/Gina (48)**/ Frank (77)/ **Kate (57) Pam (57)** →	Lucy (75)/Elsa (79)
2	**Henry (52)** →		
3	David (80)		Emma (67)
4	**Mary (58)** →	←	**Betty (49)**/Jean (72)/ Matt (60)

**Bolded names show a not clear classification after analyzing coded segments. The arrows show the trend of the other coded segments.*

Analyzing the context and the participants' answers, we concluded that other factors such as teaching out-of-field or teaching for the first time a science content, independently of the number of years of teaching experience, could have an impact in teachers' level of reflection. For instance, Betty, a 5th-year biology teacher, had coded segments as CCR, such as: "*Well, obviously, I want them to learn science concepts, that's important for scientific literacy. But, I also want them to be able to like think and do critical thinking and be able to analyze things and I want them to be able to organize data and be able to come up with conclusions and arguments and back up what they're saying with evidence.* (CCR-3, 12/01/2016; line 72)". However, she used UR in segments where she described her chemistry course, a new course she was teaching, out of her original biology endorsement. Betty described her chemistry course as "getting things done for now" (UR-2): "*I mean, I really, for chemistry, I'm just taking it day-by-day because I have no idea what I'm doing and I'm just going.* (UR-2, 12/01/2016; line 128). Even though Betty was an experienced teacher using CCR in most of her interview, she applied UR when talked about the courses she was teaching out-of-field (a course different from her original endorsement area). Consequently, these also happened to Paula, the first-year participant. All the other participants classified as CIR were teaching in-field (in their original endorsement area) courses.

Also, collaboration seemed to be a factor that influence participants' level of reflection. Teachers' used CCR when they were involved in whole-school professional development (e.g., "*We had staff meeting yesterday, my principal and I did a… an activity with the rest of the staff of… for this Danielson [model of instruction] and… he hands it out different scenarios and they had to identify which part of the model, the teaching model where they came from, and so… and what we're going to go forward with that is okay would this person be ranked as basic, or proficient, or distinguished, or unsatisfactory or how would we do it. And so, things like that, I think the whole school is kind of on a transition to being much more reflective and… in that way"* [Henry's interview, 09/21/2016; line 90]) and reflected with other teachers (e.g., "*One of the new teachers at the school, me and her actually graduated on the same year of high school, so… We talked quite a bit about things like that. I guess that's probably more like extracurricular talk too, and [we] talk about like well this, we did this yesterday and this didn't work. Then, I'll kind of give her ideas too about like lots of like classic, like last year this is what I ran into and stuff like that so... [Kate's interview,11/10/2016; line 5]*), also confirming the social component of reflection. On the other hand, teachers isolated or being the only teacher of a course in the school (e.g., Mary, the only teacher in her private school teaching science and biology) used a lower level of reflection.

Finally, our findings suggest that teachers tend to use more CIR when they have the habit of documenting their lessons to plan or assess their teaching (e.g., "*And I have for that particular lesson like 5 or 6 okay let's make these macro changes on this particular lesson cause that would help next year's class. And I go say having iterative class and that I take the feedback at each year of what didn't and did work and then updated and change it for next year's class cause if you keep doing that eventually it'll be semi-decent, right?* (Frank's interview, 11/29/2016; line 87), and reflect after assessment practices (e.g., "*I look at the quiz x, usually the kids that struggle, you know, they come and retake it the next Monday, and I do a short re-teaching session* [Emma's interview, 11/02/2016; line 29]).

Table 5. Participants' Levels of Reflection and Inquiry-Based Instruction (EQUIP mode).

Years of teaching experience	Unconscious reflection (Mode)	Conscious informed reflection (Mode)	Conscious critical reflection (Mode)
0	Paula (2)		
1		Steve (1)/ Frank (3)/ Kate (2) Pam (2)	Lucy (3)
2	Henry (2)		
3			Emma (3)
4	Mary (2)		Betty (3)/Matt (2)

Similarly, and according to the participants, the themes that emerged as the mediating factors that teachers perceived as assisting their use of reflective practices were collaboration among teachers (from science or other disciplines) (76% of the participants mentioned this theme), setting goals at the beginning of the school year and follow up meetings with science supervisors, mentors, or first-year teachers' institutes (60% of participants), and whole-school professional development and administrators' involvement (27% of participants). Also,

teachers with an open attitude toward change and improvement appeared to use these opportunities more often to think about their teaching (20%). As limitations, 33% mentioned that setting goals at the beginning of the school year without a supervisor's follow up becomes busy-work and does not promote reflective thinking; new teachers (or teaching out-of-field) found difficulties reflecting upon their teaching when they were busy preparing new materials or working on several different activities at the same time that required their attention (47% of participants).

After analyzing the EQUIP coded classroom observations (from the larger study) to identify a level of inquiry instruction and related them to the participants' level of reflection (Table 5), we found that the most common level of inquiry based on EQUIP was "developing" inquiry teaching (i.e., 2). Therefore, we found "developing inquiry" in all levels of reflection. However, CCR participants tended to have a higher level of inquiry instruction (i.e., 3, "proficient inquiry") compared with UR (i.e., 2, "developing inquiry").

DISCUSSION AND CONCLUSIONS

Reflection has been considered for teacher preparation programs and schools as a necessary practice for new teachers and a tool for learning how to teach science (McGregor, 2011). For this study, we had three questions about teachers' reflective practices: (1) What are beginning science teachers' reflective practices after finishing their teacher preparation program? (2) What factors may affect beginning science teachers' reflective practices? And, (3) what is the relationship (if any) between reflective practices and inquiry-based instruction? Based on our findings we will try to answer them.

Beginning science teachers' reflective practices (research question 1)

Analyzing the level of the participants' reflection based on Cartwright (2011), we found that we coded segments using the three levels of reflection for almost all participants. Larrivee (2008b), who developed similar levels of reflection to Cartwright (2011), explained that a reflective practitioner incorporates all levels of reflection. Therefore, it is common to find all levels when a teacher reflects about a teaching event.

Although there were all levels of reflection in participants with the same amount of years of teaching experience, in general, we found that beginning teachers require experience to deepen their level of reflection. Participants teaching in-field and with more than one year of teaching experience tended to use CIR and CCR. This is, teachers use their past experiences to inform their teaching and make instructional decisions. For example, Betty, a fifth-year biology teacher teaching for the first time a chemistry course, tended to use CCR in the interview. However, she used UR when she referred to her chemistry classroom. In the case of Paula, the first-year teacher, her reflection during the interview was dominated by UR segments. Cartwright (2011) explained that teachers learn from their own and others' experiences. Reflection on past experiences and learning strategies can develop teachers' self-efficacy and understanding of themselves as learners (Mycroft & Gurton, 2011). Therefore, experiences can help teachers develop deeper reflection about their strategies. Conversely, a lack of experience might promote superficial reflections that do not lead to improvement.

Factors affecting reflective practices (question 2)

Teachers' reflective practices are complex and not static. Teaching experience can support teachers' deeper reflection but there are other factors, such as the context where the reflections are made, the collaboration with others, and an opened attitude toward change, that might have an influence as well. Malthouse, Roffey-Barentsen, & Watts (2014) defined context as the physical surroundings, social setting, and individual dispositions contributing to the quality of reflection. Therefore, all the later elements might have affected the participants' level of reflection. For instance, busy teachers might tend toward more superficial reflections than those who have more time to stop and think about the past. Also, isolated teachers tend to more unconscious reflection compared to those teachers who have peers or mentors to think about their goals, challenges, and expertise development.

York-Barr, Sommers, Ghere and Montie (2006) viewed reflective teaching as related to collaboration and practice. They came up with the idea that reflection can be performed in four interconnected levels of a spiral that includes individual reflection, reflection with partners (e.g., another teacher, a mentor), reflection in a small group or team, and finally, school-level reflection practice that can result in a "cumulative effect on school wide practices and learning" (p. 21). Our findings support that the outer levels of this spiral (i.e., school and group reflection) will support deeper levels of reflection. The later might be because these outer levels of the spiral create a supportive environment for teachers to grow and adopt a specific practice.

Moreover, other researchers have also supported the importance of the context in which reflection takes place. Edwards and Thomas (2010) insisted that educators should be concerned with developing supportive contexts to enhance reflection as part of social conduct. They argued that the context in which teachers solve problems will have a significant impact in their decisions. Collin et al. (2013) agreed that context might influence teachers' ability to reflect. Supportive school environments can provide opportunities to reflect that will enhance teachers' reflective abilities and metacognition. Larrivee (2008a) explained that "even novice teachers can deepen their level of reflection with powerful facilitation and mediation within an emotionally supportive learning climate" (p. 346). Therefore, a supportive environment in schools where teachers, administrators and the community are involved in teaching science as inquiry will be more effective supporting teachers' deeper levels of reflection.

Relationship between reflective practices and inquiry-based instruction (question 3)

There is a general agreement that reflective practices can improve teaching and learning in the classroom (e.g., Belvis, Pineda, Armengol, & Moreno, 2013). We agree that any level of reflection can help teachers improve their practice (Cartwright, 2011) and that no difference exists between "good" or "bad" reflection (Collin et al., 2013). The effectiveness of reflection depends on multiple factors, such as the purpose, teachers' goals, etc. However, McGregor (2011) found that deepening the level of reflection can make it more meaningful and support teaching improvement and creativity more effectively than lower levels of reflection. The later aligns to our preliminary findings, after analyzing the EQUIP coded lessons. In general, participants in CCR tended to have better inquiry rates than teachers mostly using unconscious reflection.

Conclusions

Some of the lessons learned after this study rely on the idea that beginning teachers' reflective practices are complex and not static. Teaching experience can support teachers' deeper reflection (CCR) but there are other factors (e.g., teaching out-of-field, collaboration, whole-school professional development) that might have an influence as well. Therefore, we conclude that TEPs, schools and learning communities need to promote collaborative reflective environments to prepare teachers to become deeper critical thinkers about their professional careers and their proficiency applying inquiry-based strategies.

Moreover, we acknowledge that the participants' level of reflection during our conversations did not represent the way they reflected all the time and that our bias could have affected our coding of their statements. Instead, our purpose was to understand some of the differences in their reflective practices, as part of their conceptual change as beginning science teachers. We found Cartwright's (2011) levels of reflection adequate to analyze reflective practices and their descriptors as a good tool to promote deeper reflection in TPP or schools. Additionally, understanding some factors that might have an influence teachers' reflection could support the understanding of this skill and its social dimension. Therefore, Cartwright's (2011) levels of reflection could be used as a tool to promote/support/analyze more conscious critical reflection and apply a higher level of inquiry instruction for science teachers during their induction phase.

Finally, applying the descriptors used by Cartwright (2011) and additionally to our findings, we noticed a lack of explicit concern about equity issues in the tool and the participants' comments during these interviews. This was despite the fact that during their student teaching experiences they were largely placed in highly diverse school settings during their teaching preparation program and many of them were teaching at high-needs schools. Our suggestion would be to include descriptors connected to teaching for all students as part of a critical reflection.

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REFERENCES

Belvis, E., Pineda, P., Armengol, C., & Moreno, V. (2013). Evaluation of reflective practice in teacher education. *European Journal of Teacher Education*, 36(3), 279–292.

Cartwright, L. (2011). How consciously reflective you are? In D. McGregor & L. Cartwright (Eds.) *Developing Reflective Practice* (pp. 55-68). New York, NY: McGraw Hill Open University Press.

Collin, S., Karsenti, T., & Komis, V. (2013). Reflective practice in initial teacher training: Critiques and perspectives. *Reflective Practice*, 14(1), 104–117.

Duffy, G. G., Miller, S., Parsons, S., & Meloth, M. (2009). Teachers as metacognitive professionals. In D. J. Hacker, J. Dunlosky, & A. C. Graesser (Eds.), *Handbook of Metacognition in Education* (pp. 240–256). New York: Routledge.

Edwards, G., & Thomas, G. (2010). Can reflective practice be taught? *Educational Studies*, 36(4), 403–414.

Korthagen, F., & Vasalos, A. (2005). Levels in reflection: Core reflection as a means to enhance professional growth. *Teachers and Teaching: Theory and Practice*, 11(1), 47–71.

Larrivee, B. (2008a). Development of a tool to assess teachers' level of reflective practice. *Reflective Practice*, 9(3), 341–360.

Larrivee, B. (2008b). Meeting the challenge of preparing reflective practitioners. *The New Educator*, 4(2), 87–106.

Malthouse, R., Roffey-Barentsen, J., & Watts, M. (2014). Reflectivity, reflexivity and situated reflective practice. *Professional Development in Education*, 5257(August 2014), 1–13.

Marshall, J.C., Horton, B., Smart, J, & Llewellyn, D. (2008). *EQUIP: Electronic Quality of Inquiry Protocol:* Reviewed from Clemson University's Inquiry in Motion Institute, https://www.clemson.edu/education/research/centers-institutes/inquiry-in-motion/research-evaluation/equip.html

Marzano R.J., Boogren, T., Heflebower, T., Kanold-McIntyre, J., & Pickering, D. (2012). *Becoming a Reflective Teacher*. Bloomington, IN: Marzano Research.

McGregor, D. (2011). What can reflective practice mean for you… and why should you engage in it? In D. McGregor & L. Cartwright (Eds.), *Developing reflective practice* (pp. 1-19). New York, NY: McGraw Hill Open University Press.

Miles, M.B., Huberman, A.M., & Saldana, J. (2014). *Qualitative Data Analysis: A Methods Sourcebook* (3rd ed.). Washington, DC: SAGE.

Mycroft, L., & Gurton, P. (2011). How can you use reflection to develop creativity in your classroom? In D. McGregor & L. Cartwright (Eds.), *Developing reflective practice* (pp. 107-125). New York, NY: McGraw Hill Open University Press.

Parker, J., & Heywood, D. (2013). Exploring how engaging with reflection on learning generates pedagogical insight in science teacher education. *Science Education*, 97(3), 410–441. doi:10.1002/sce.21049

Russell T., & Martin, A. (2014). Learning to teach science. In N.G. Lederman & S.K. Abell (Eds.). *Handbook of Research on Science Education* (pp. 871-888). New York, NY: Routledge Taylor & Francis Group.

White, B., Frederiksen, J., & Collins, A. (2009). The interplay of scientific inquiry and metacognition: More than a marriage for convenience. In D.J. Hacker, J. Dunlosky, & A.C. Graesser (Eds.), *Handbook of Metacognition in Education* (175–205). New York, NY: Routledge Taylor & Francis Group.

York-Barr, J., Sommers, W. A., Ghere, G. S., & Montie, J. (2006). *Reflective Practice to Improve Schools: An Action Guide for Educators* (2nd ed.). Thousand Oaks, CA: Corwin Press.